

Development of a Full SLR Software Stack Based on Real Time Linux

and

a New Version of the Potsdam Range Gate

André Kloth & Jens Steinborn

19th International Workshop on
Laser Ranging

- **SCOPE: SLR Control & Operation Software**
- In 2011 SpaceTech (STI) did a major redesign and re-implementation of operation software for SLR station in Potsdam/GFZ
 - Enhance performance & maintainability
 - Use of still existing expertise in upgrade process
 - State-of-the-art operating system with continuous long-term support
 - Efficiency improvement
- Since September 2012 system is in productive operation
→ **Ensures operation for the next decades!**

- Following the successful upgrade approach at GFZ, STI was contracted by Finnish Geodetic Institute (FGI) for integration of its SLR software, Range Gate and operations support in 2014
- FGI currently builds a new kHz SLR system from scratch

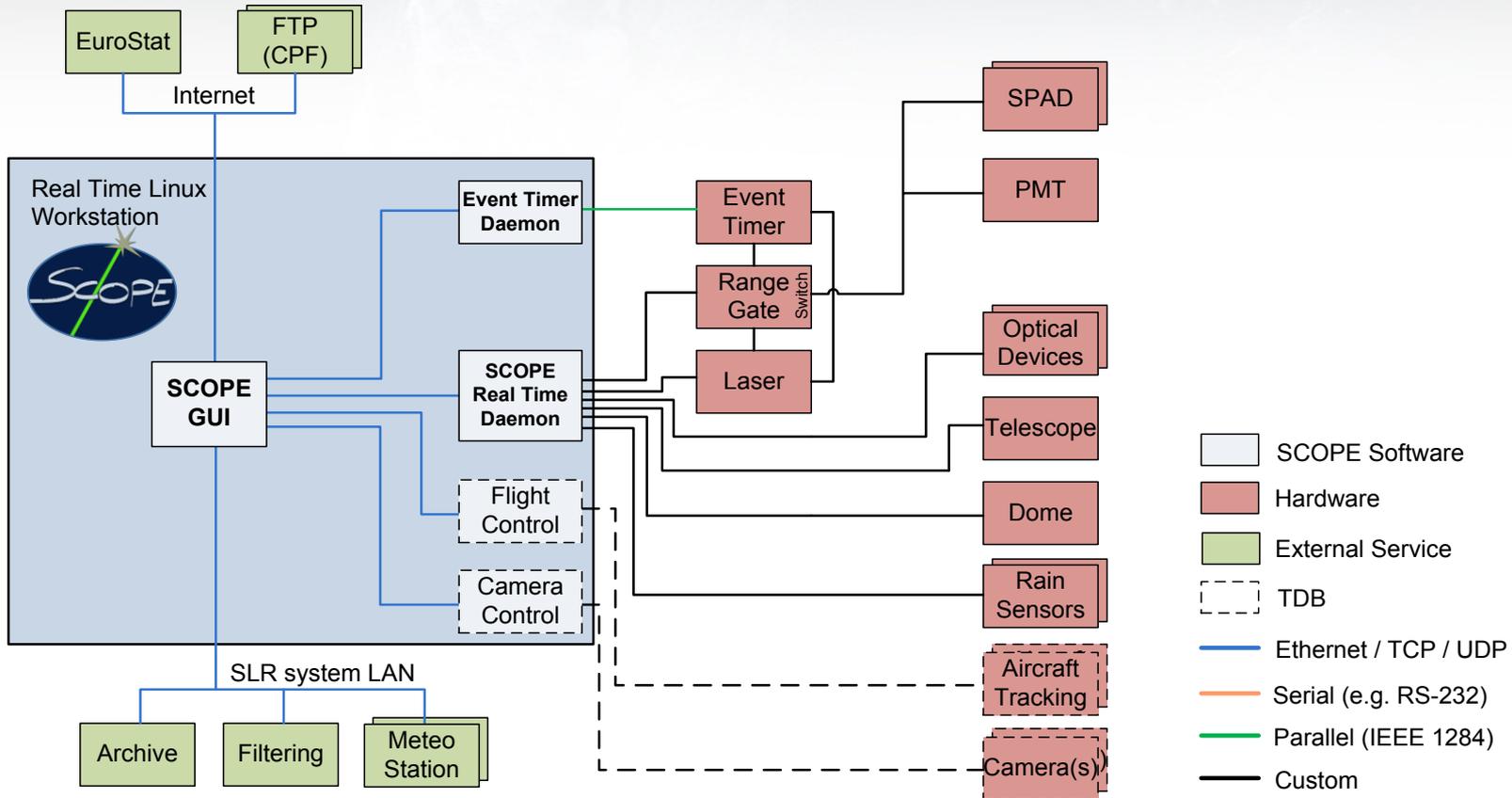
→SpaceTech supports system design/engineering and provides experience about all details of SLR

SCOPE – SLR Control & Operation Software



- Providing complete software stack for SLR operations

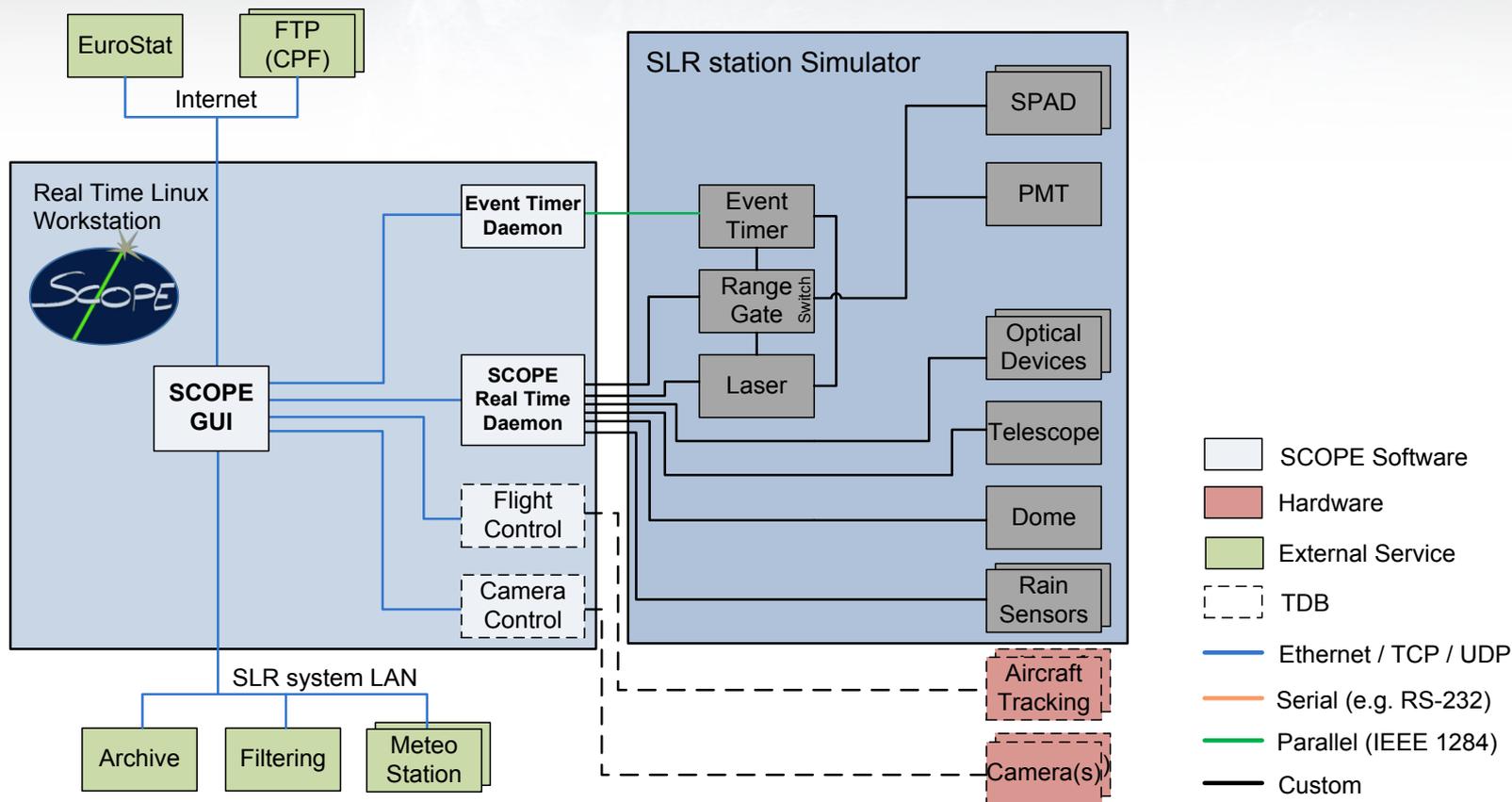
- SCOPE (GUI, Real Time & Event Timer Daemon)
- SLR filter software
- SLR station simulator



SCOPE – SLR Control & Operation Software



- Providing complete software stack for SLR operations
 - SCOPE (GUI, Real Time & Event Timer Daemon)
 - SLR filter software
 - **SLR station Simulator**



- 1. Engineering activities of identifying and specifying necessary interface adaptations and software extensions**
- 2. SLR station Simulator for system development & verification**
 - Minimized risk of damaging hardware (e.g. allows damage “free” error injection)
 - Validation of timing behavior and low level hardware access without available hardware
 - Optimal tool to test special cases (over-mid-night and high-speed tracking, sun avoidance)
 - Replay of observations for e.g. testing different algorithms & parameters (e.g. echo detection, automatic angle/time bias correction, etc.)
 - Gradual exchange of simulated hardware modules by real hardware

- STI's system expertise for future commissioning of complete SLR system
- **GFZ and FGI will share the same software code base**
 - Easier integration of new modules e.g. for space debris tracking!
 - Both SLR systems benefit from software updates and improvements
 - Easier exchange of operational knowledge, add-on software

Impressions – SCOPE screenshots



The screenshot displays the SCOPE software interface, which is used for satellite laser ranging. The interface is divided into several sections:

- Top Left:** A sidebar menu listing various satellites and their observation times, such as Galileo, Olomass-109, and Grace.
- Top Center:** An "Elevation Plot" showing the elevation of the selected satellite over time. The plot includes a red line for the maximum elevation and a blue line for the minimum elevation.
- Top Right:** A "Details" panel for the selected satellite, "cryosat2". It provides key parameters: Type: Single, Target: cryosat2, CPF file: ESA7061, Begin: 11:24:53, Duration: 00h 06' 51", End: 11:31:44, Min Range: 728.65 km, Max Range: 1638.78 km, Min El.: 20.00, Max El.: 86.22, Max Speed (Az): 8.88, Max Speed (El): 0.59, High Speed: no, Sun Interference: yes.
- Bottom Left:** A "Tracking" window showing a real-time plot of "Deviation from Predicted Time of Flight / Calibration (ns)" versus time. The plot shows a red line representing the current deviation and a green horizontal line at the bottom representing the predicted time of flight.
- Bottom Center:** A status bar displaying observation parameters: CospasID: 0702601, Target: terrasax, Source: GFZ7422, Begin: 16:24:37, End: 16:29:38, Duration: 00h 05' 01". It also shows "Echos 7.158" and a "2% total" signal strength.
- Bottom Right:** An "Offset Telescopes" control panel with settings for Azimuth (Az) and Elevation (El) offsets, time bias, gate size, prefilter window, and scale size. It also includes a small circular plot showing the telescope's current position.

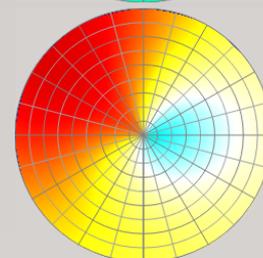
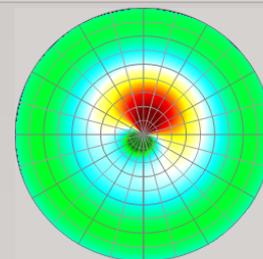
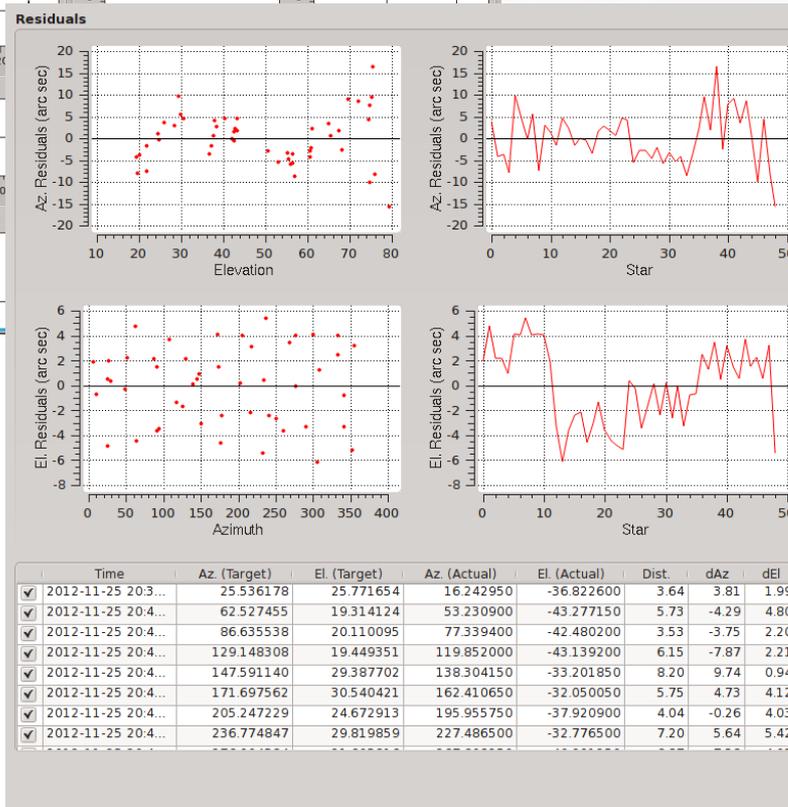
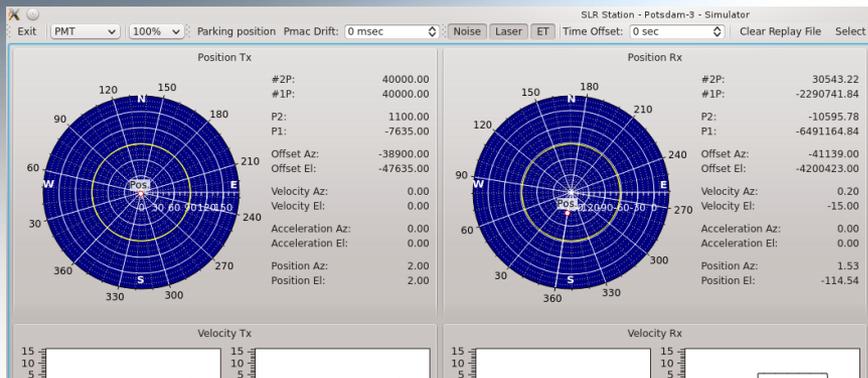
The interface is running on a Linux system, as indicated by the taskbar at the bottom showing the window title "SLR Station - Potsdam-3" and system information like "1007.78 mbar 25.92°C 43.90% A032-ET 2kHz PMT 1700 V ET: Measurement RTD: SatelliteTracking Tx / Rx".

Main
Observation
Frontend

Impressions – SCOPE screenshots



SLR station Simulator



Param	Delta
1	-9.225824
2	-4.808794
3	12.897250
4	5.240150
5	-15.438910
6	-20.667802
7	7.865987
8	-1.733783
9	-0.692933
10	3.599068
11	-3.492598
12	-11.672897
13	9.350596
14	9.456961
15	-12.039168
16	3.697070
17	-4.526046
18	-7.322225
19	0.785163
20	0.439727

Mounting model

RMS (Az): 5.8883°
 RMS (Az) cos(El): 3.0894°
 RMS (El): 3.1086°

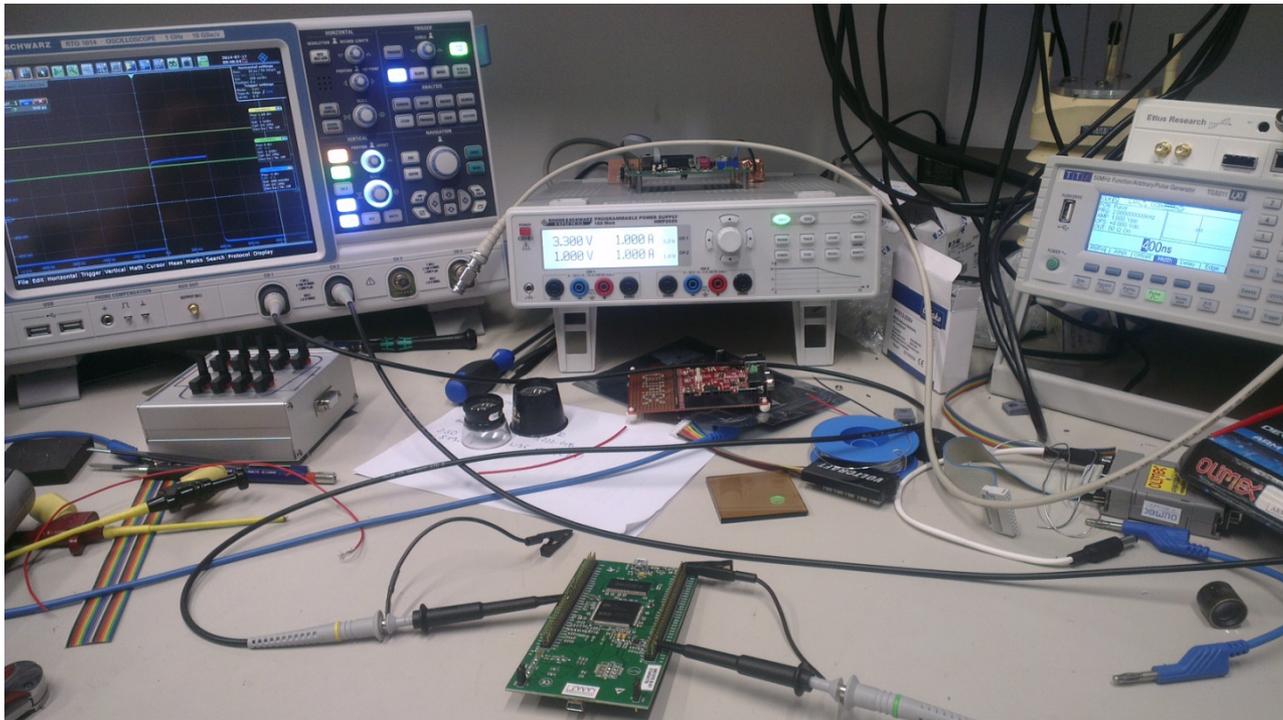
Close Save Match Iterate

Mount Model Calculations

Enhancements of SCOPE & new Range Gate



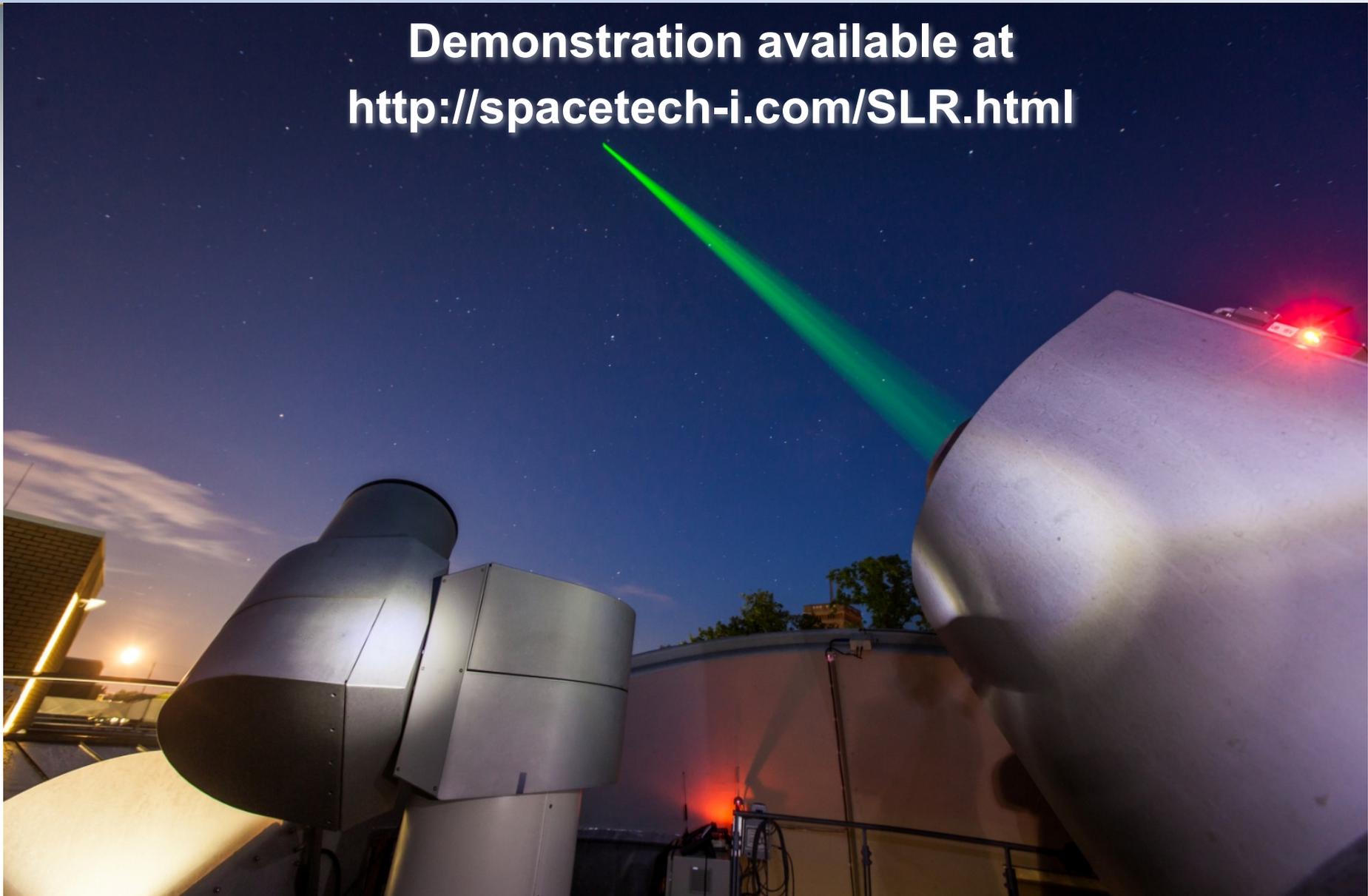
- Current enhancements for FGI/Metsähovi
 - Support for automatic dome control
 - Single telescope operation mode (two separate telescopes at GFZ)
 - New software interfaces and drivers for meteo, time synchronization / GPS receiver, filter/shutter, ...
 - Improved range gate & newer event timer A033-ET from Riga



Range Gate
Development
based on ARM
Cortex-M4

- Future goals and planned software upgrades
 - Space debris tracking as “joint tracking” together with other SLR stations
 - All-sky camera support for cloud monitoring
 - Automatic star observation for mount model generation (beta status)
 - Integration of automatic aircraft flight safety
 - **Full & semi-autonomous operation** of SLR system (track scheduling, tracking, advanced monitoring of status/environmental data, filtering, reporting, ...)
 - Laser communication

**Demonstration available at
<http://spacetechnology.com/SLR.html>**



- Support for $\geq 2\text{KHz}$ Laser firing frequency
 - Consistent frontend for all tasks
 - System initialization, calibration procedure, all observation modes including sun avoidance, high-speed tracking, tandem, interleaving, re-attaching to running track, etc.)
 - Planning (preparation of prediction data)
 - Star observation for creating mounting models
 - Interfaces to telescopes, event timer, range gate, optics control, meteo data, GPS time reference (synchronisation) by 1PPS signal, filter, shutter, post-processing of measurements, etc. (profiles for different configurations)
 - Automatic retrieval of orbit predictions (CPFs)
 - Time / elevation plot of satellite tracks for an arbitrary time frame including Keplerian elements calculation
 - Configurable tracking profiles for single satellites and tandem satellites; simple switching between satellites
 - Support for interleaving tracking (e.g. TanDEM-X & TerraSAR-X) and night-only tracking
 - Automatic sun avoidance for telescope movement
 - Automatic split of high speed tracks alt-azimuth telescopes
- **This slide ends here, but the features list don't**

